DEPARTMENT OF THE ARMY
U.S. ARMY DUGWAY PROVING GROUND
DUGWAY, UTAH 84022-5000

REPLY TO
ATTENTION OF:

MAY 27 2009

TEDT-DPW-CTC

MEMORANDUM FOR U.S. Army Developmental Test Command (TEDT-DTC-TMA/C. Pritts), 314 Longs Corner Road, Aberdeen Proving Ground, MD 21005-5055

SUBJECT: Event Record for the Joint Chemical Agent Detector (JCAD) Increment 2 Chamber Upgrades, U.S. Army Test and Evaluation Command (ATEC) Project Number 2009-DT-DPG-JCADX-E1350, West Desert Test Center (WDTC) Document Number WDTC-ER-09-034

1. Background:

a. Date of Test: 7 January through 17 March 2009

b. Authority: Support requested by Joint Project Manager Nuclear Biological Chemical Contamination Avoidance (JPM NBC CA) and Operational Test Command (OTC). On 8 October 2008, the U.S. Army Developmental Test Command (DTC), Aberdeen Proving Ground (APG), Maryland activated the U.S. Army Test and Evaluation Command (ATEC) Decision Support System (ADSS) account authorizing WDTC, U.S. Army Dugway Proving Ground (DPG), Utah, to support the JCAD Increment 2 Chamber Upgrades, ATEC Project Number 2009-DT-DPG-JCADX-E1350.

2. Item Description: The JCAD is a point chemical warfare agent (CWA) detector designed to alert the warfighter to a range of chemical threats.

3. Test Description: The JCAD 2 test chamber was upgraded and tested in five phases as follows:

a. The dissemination system was upgraded and tested.

(1) The upgraded prototype dissemination system's various component functionality was verified (e.g., flow controllers, thermocouples, valves, and heaters). **NOTE**: Table 1 lists the major differences between the upgraded (prototype) and previous dissemination systems.

(2) Once the general system's flow characteristics were established and deemed satisfactory, the dissemination trials began. The simulants [methyl salicylate (MeS) and dimethyl methyl phosphate (DMMP)] were chosen for their similarity to CWA evaporation characteristics and for the ease of monitoring by the MINICAMS® (a miniature, automatic, continuous air-monitoring system).

(3) Airflow, simulant-dispensing rates, air temperature at various points, and final simulant concentrations were measured and recorded. Air phase concentrations were measured and recorded using two calibrated MINICAMS® detectors.

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Table 1. Differences Between the Previous and Upgraded Dissemination Systems; JCAD Increment 2 Chamber Upgrades.

Feature	Current System	Model
Air delivery	House air is delivered directly to heated evaporation “tee.”	House air will be preheated. The air will be used to heat the evaporation “tee.”
Agent introduction	The syringe pump drives a syringe with a fixed needle through a septum located on the heated evaporation “tee.”	The needle and septum will be replaced with tubing and fittings (this is the major place of human interface).
Wetted materials	Materials are composed of mostly stainless steel.	To minimize stainless steel/agent interaction, the steel will be replaced with PFA/FEP[a].
Temperature monitors	Temperature is monitored externally.	Air temperature will be monitored directly (Figure 1).

[a]Perfluoroalkoxy/fluorinated ethylene-propylene.

b. The prototype dissemination system was set up and tested.

(1) The prototype dissemination system was assembled in the laboratory and placed in the fume hood. Electronic controls and monitoring equipment were placed adjacent to the hood.

(2) The flow and temperature controls were tested.

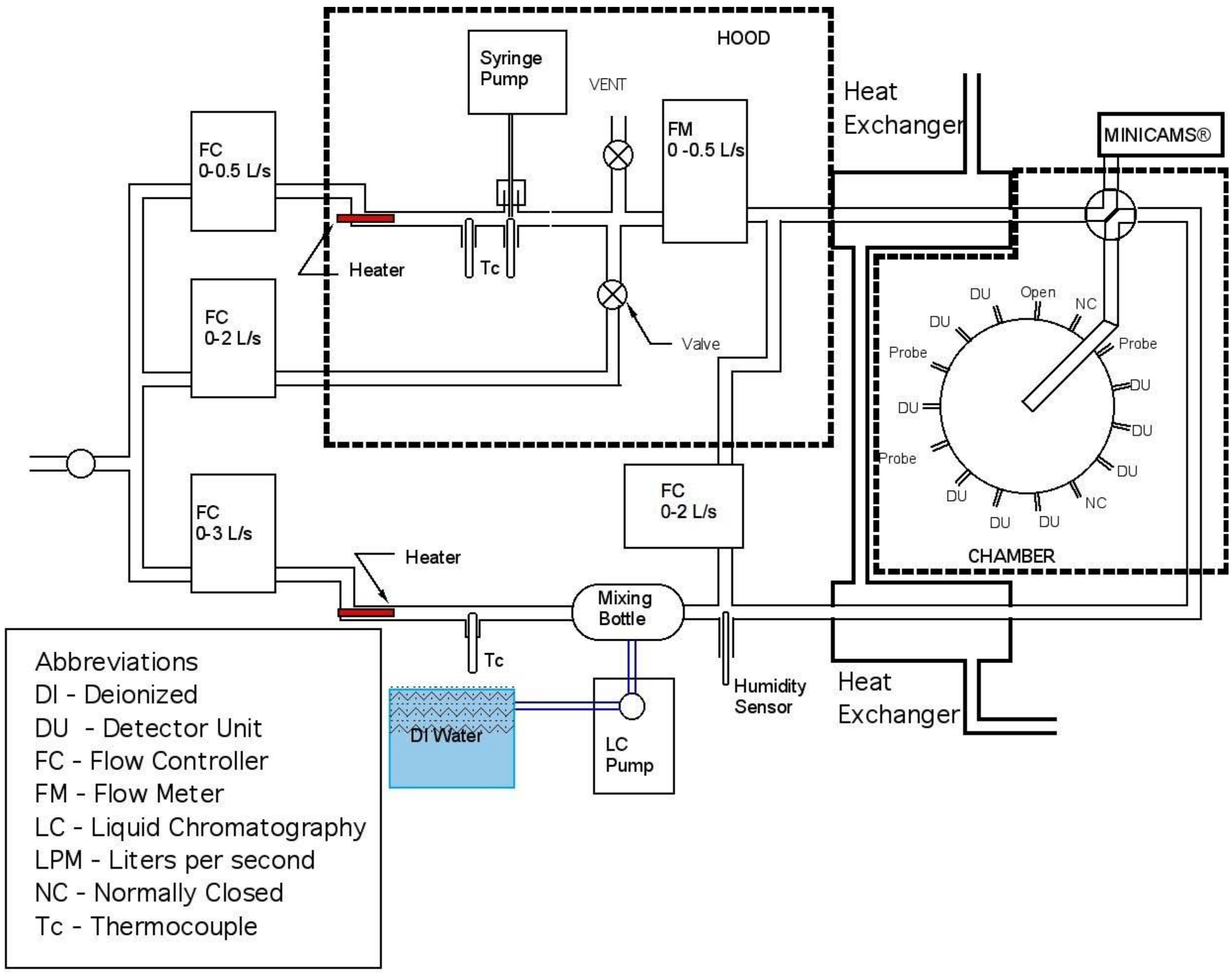
(3) Flow and temperature controls for the entire test fixture system were checked. The syringe pump was also checked to ensure that it was operating properly.

c. Test operations were conducted.

(1) Simulant was introduced at a known rate into the air stream, and the concentration was monitored in the outlet air after dilution.

(2) Airflows and simulant infusion rates were varied to span the concentration ranges used in actual CWA testing. In actual trials, airflows from 5 to 20 L/min and infusion rates of 0.01 to 1 µL/hr are typically used to produce target concentrations of agent or simulant in the diluted air stream of 0.0001 and 30 mg/m^3.

(3) After the concentration of simulant reached a steady state, infusion was halted and clear-down times were observed and recorded.



NOTES: 1. The dissemination section located in the hood is described in Paragraph 2.1 of the Methodology Investigation Plan for the Joint Chemical Agent Detector (JCAD) Increment 2 Chamber Upgrades, January 2009. Heat exchangers were added to precondition the environment and purge air streams to the desired test temperature.
2. MINICAMS® – a miniature, automatic, continuous air-monitoring system.

Figure 1. Summary Schematic of Modified Chamber Plumbing; JCAD Increment 2 Chamber Upgrades.

d. The JCAD chambers were upgraded.

(1) Purified water was obtained for humidification. During testing, a plastic jug was filled with deionized (DI) water at the Combined Chemical Test Facility (CCTF) and transported to the Bushnell Materiel Test Facility (BMTF). The water, jug, and receptacle in the test

chamber were inspected to ensure that no visible contamination had occurred. Before testing began, the water level was inspected to ensure that an adequate amount was present.

(2) The JCAD Chamber 3 was upgraded to Increment II Gate 1 functionality levels. A new four-way valve, a Delrin® (E.I. du Pont de Nemours and Company, Wilmington, Delaware) radial distribution manifold (RDM), and a liquid chromatography (LC) pump for humidification were installed in chamber 3.

(3) Lines and cables were labeled. All lines entering the test chambers were clearly labeled electrical, air, or liquid.

(a) For lines longer than 1 m, both ends of the lines were labeled.

(b) All valves, switches, and remote instrumentation were clearly labeled.

(c) The labeling scheme was documented.

(d) All changes were documented and proper labels were affixed as needed.

e. Air streams were merged and preconditioned.

(1) The environmental and purge air streams were merged. A single humidified air stream was produced with twice the flow, and the flow was split into two equal air streams. One stream received the small flow of agent-containing air from the dissemination system and the other remained clean. Before introduction to the RDM, the air streams passed through heat exchangers in order to bring the air to the proper temperature for the test (Figure 1). **NOTE**: Humidification generally required that the air was heated and maintained at a temperature of 5 to 10°C or more above its dew point to prevent condensation in the lines.

(2) Special flow controllers (FCs), that are able to keep functioning even if small amounts of liquid water run through them were purchased. A spare FC was kept for each chamber in case of a breakdown.

(3) One regular FC from the current setup was removed to further simplify the system.

(4) All stainless steel lines and fittings that transport agent were replaced with lines and fittings composed of perfluoroalkoxy (PFA) (or equivalent).

(5) Air for the merged streams was preconditioned and heat exchangers were installed. These changes were made in a single chamber first. Then a verification and validation test was performed, and each corrective action was implemented and verified before changes were made to the remaining two chambers.

(6) Chiller lines were re-insulated: fluid temperatures were measured at the chamber and at the chiller return line to test whether the insulation was adequate.

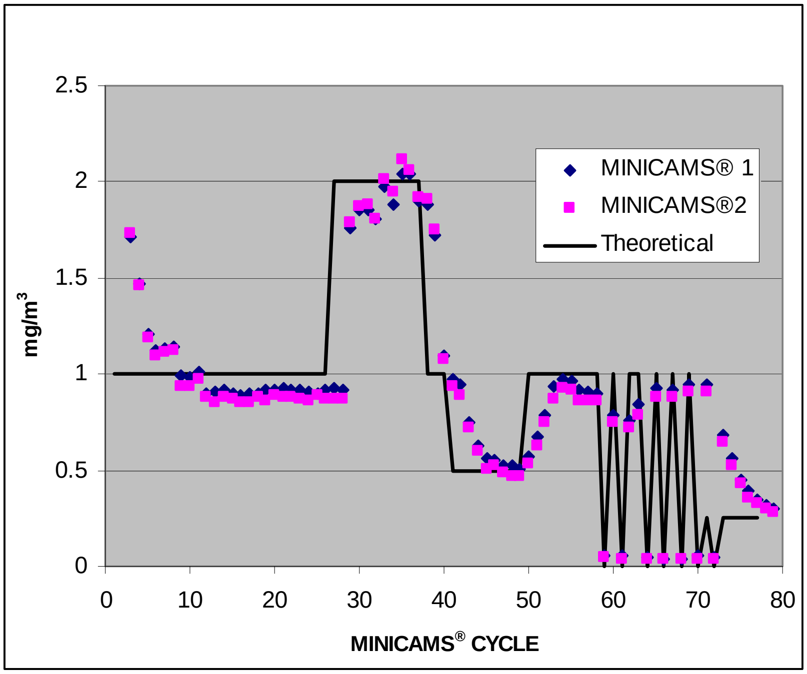
4. Test Objectives:

a. Build, test, and evaluate several new conceptual upgrades in the agent dissemination subsystem of the JCAD test fixture.

b. Apply selected upgrades to improve chamber performance.

5. Summary of Results:

a. All test objectives/criteria (see Methodology Investigation Plan for the JCAD Increment 2 Chamber Upgrades, ATEC Project Number 2009-DT-DPG-JCADI-E1350) for MeS were met (Figure 2); however, the DMMP trials were not as successful. The following DMMP problems were encountered:



NOTES: 1. Figure shows excellent agreement between results from the two MINICAMS® units as well as reasonable agreement between the theoretical dissemination rate and the measured concentration.

2. The temperature in the evaporation zone was controlled at 150ºC.

Figure 2. Methyl Salicylate (MeS) Dissemination Data in the Prototype System From 17 March 2009; JCAD Increment 2 Chamber Upgrades.

(1) Stable concentrations were seldom achieved.

(2) Good mass balance was never achieved.

(3) When using the original alumina (Al_2O_3) wetting surface [Paragraph 5.b(9)] up to 98 percent of the infused DMMP was lost. Replacement with a glass surface corrected this problem.

(4) Additional literature research also revealed some very unusual Teflon®-water-DMMP interactions as the probable source of difficulties outlined in Paragraphs 5.a(1) through (3). It is likely that similar issues will arise in attempts to disseminate nerve agents in the presence of humidity.

b. Overall lessons learned were:

(1) Preheating the carrier gas before attempting to evaporate liquid simulant worked well, provided the temperature at the site of evaporation was monitored and controlled.

(2) Insulation between the gas heater and the dissemination point is critical to the establishment and maintenance of stable temperature. The distance between these two points should be as short as practical.

(3) Suitable fittings, particularly those made of PFA, were not always available. This was particularly true when 3/8-in crosses were ordered. When fittings were available, they often had very long delivery times.

(4) As a composition material, PFA functioned well in lines and fittings through which gaseous simulant or agent was transported.

(5) When using the dissemination point temperature to control the gas heater, it was very important to allow the entire system to thermally stabilize.

(6) Suitably mounted thermocouples for this type of dissemination system are not available commercially.

(7) Additional dissemination methodology work should be performed at the CCTF to incorporate an air dryer on the compressed-gas line.

(8) When joining PFA (or other Teflon®) tubing sections to fittings, the appropriate grooving tool should be used. When flare style fittings are needed, the appropriate flare tools should be available.

(9) Smooth dissemination requires that the challenge liquid be placed on a wetted surface to ensure evaporation. Glass functions well as an evaporation plate (see Figure 3 for evaporation plate location). It is expected that quartz (fused silica) would function even better than glass.

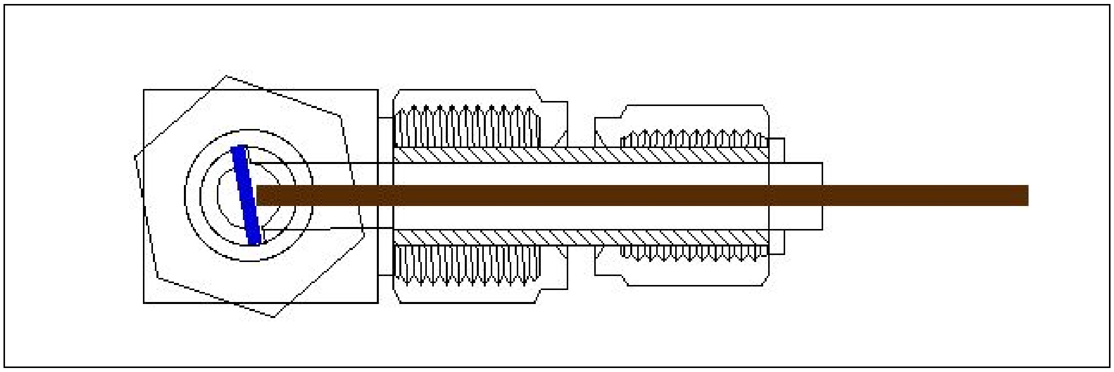


Figure 3. Perfluoroalkoxy (PFA) T with Glass Evaporation Plate (Blue) and Capillary (Brown); JCAD Increment 2 Chamber Upgrades.

(10) Replacement of the needle and septum with a capillary and fitting arrangement worked well.

c. Chamber Upgrades:

(1) <u>DI Source</u>

(a) Test personnel found that the quickest, cheapest, and most reliable source for DI water source was the DI water supply in the CCTF. Several liters were transported each day to the test chamber. In the chamber, the DI water was placed in a reservoir and delivered to the high performance liquid chromatography (HPLC) pumps.

(b) <u>Lesson Learned</u>. The available HPLC pumps at DPG are incapable of pulling water up-hill; therefore, the water reservoir must be located above the pump or the water pressurized.

(2) <u>Merged Environmental and Purge Air Streams</u>

(a) This approach produced the desired uniform humidification of the environmental and purge air streams. However, it was necessary to insert low-pressure flow meters and a needle valve to regulate the relative flows. This approach is somewhat different than envisioned in Figure 2.

(b) Lessons learned were:

(<u>1</u>) In these types of setups, test personnel should be aware of pressure drop requirements for the various flow-monitoring and control systems.

(2) The PFA heat exchangers from Enteris (Chaska, Minnesota) require proprietary fittings or equipment to connect them with standard tubing. Acquisition of these special parts delayed assembly and testing.

(3) The heat exchanger performance could be improved by increasing coolant flow and/or available cooling power.

(4) Temperatures at each end of the heater/chiller lines on both the delivery and return sides were measured at several different temperatures. Temperature changes along the lines ranged from less than 1°C to less than 3°C; temperature changes across the glove box were as high as 25°C. Therefore, line insulation was adequate at this point. Glove box insulation will require additional investigation.

(5) Temperature-controlled sample lines for the MINICAMS® are not readily available from commercial sources. Further investigation of sample line difficulties, particularly difficulties with condensation, revealed that condensation tends to occur following trials conducted at high humidity. When the flow is reduced and the line heater is turned off, droplets can condense in the sample lines between the radial distribution manifold and the MINICAMS®. When the system is turned on again, the flowing gas can drive the liquid to the detector and damage the detector. To mitigate this risk, the sample lines should be diverted around the MINICAMS® to the vacuum line and left flowing continuously.

6. Trial data for this event record are in digital data repository (DDR). For additional information contact the test officer (Jonathan fields).

7. The point of contact at this test center is Jonathon Fields, DSN 789-7348, commercial (435) 831-7348, or email at jonathan.a.fields@us.army.mil.

8. Dugway Proving Ground – Rendering Danger From Chem/Bio Agents Irrelevant.

FOR THE COMMANDER

K Gratton for

JAMES P. DELANEY
LTC, AV
Director, West Desert Test Center